

# Carbon Fiber Technology Facility

**Dave Warren, PI**

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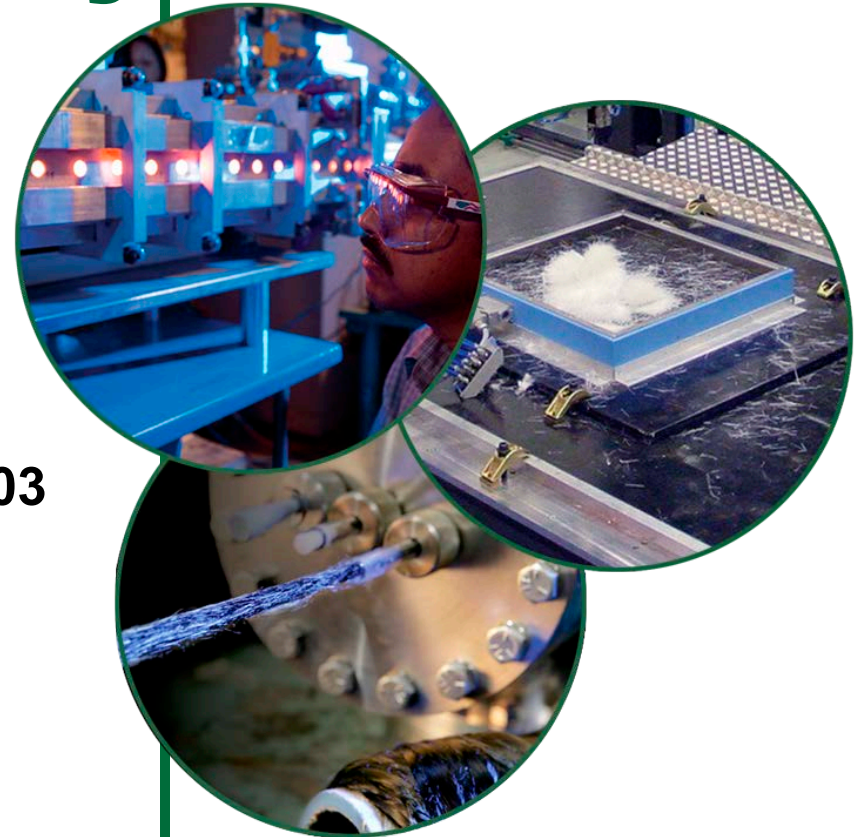
Director, Carbon Fiber Technology Facility  
Oak Ridge National Laboratory

May 15, 2013

Project ID # LM003

Status as of April 5, 2013

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# Carbon Fiber Technology Facility (CFTF) ARRA Capital Project Overview

## Timeline

- Funds received FY10Q2
- CD-2/3 FY11Q2
- Project completed (CD-4) FY13Q2
- Six months ahead of schedule, under budget

## Budget

- \$34.7M Budget
  - Capital project

## Barriers addressed

- Cost of Carbon Fiber
- Technology scaling
- Market development

## Partners and Collaborators\*

(all are U.S. companies)

- Harper, International
- Hills, Inc.
- Engineering Services Group
- Roane State Community College

\* Capital MIE project only



# The nation needs a scale-up facility for low-cost carbon fiber technology demonstration

75 Stakeholders from government and industry attended a workshop at ORNL in March 2009



**“DOE does not...possess the advanced carbon fiber research, development, and demonstration capability necessary to achieve its mission goals...need to develop a multi-industry, multi-participant technology demonstration and deployment facility that can be easily accessed by researchers and stakeholders for key industries.”**

## Relevance

3 Managed by UT-Battelle for the U.S. Department of Energy



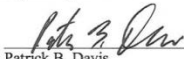
## U.S. Department of Energy Energy Efficiency and Renewable Energy

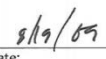
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

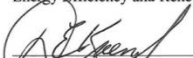
### MISSION NEED STATEMENT Critical Decision – 0

Acquiring Advanced Carbon Fiber User Research, Development, and Demonstration Capability

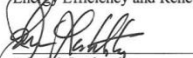
Approving Officials:

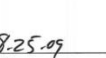
  
Patrick B. Davis  
Program Manager  
Vehicle Technologies Program  
Energy Efficiency and Renewable Energy

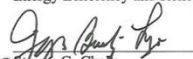
  
Date: 8/19/09

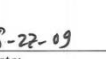
  
Douglas E. Kaemp  
Program Manager  
Industrial Technologies  
Energy Efficiency and Renewable Energy

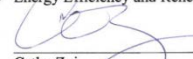
  
Date: 8/19/09

  
John M. Lushetsky  
Acting Deputy Assistant Secretary  
For Energy Efficiency  
Energy Efficiency and Renewable Energy

  
Date: 8-25-09

  
Steven G. Chalk  
Chief Operating Officer  
Energy Efficiency and Renewable Energy

  
Date: 8-22-09

  
Cathy Zoi  
Assistant Secretary  
Energy Efficiency and Renewable Energy

  
Date: 8/17/09

# CFTF will enable introduction of large scale low-cost carbon fibers (LCCF) into U.S. markets

- Structural carbon fiber has a variety of light-weighting applications
  - Defense: Heat shields, aircraft wings and fuselages, lightweight weaponry
  - Automotive: 10% mass reduction equates to 6-7% increase in fuel economy
  - Wind energy: 100 m wind turbine blades for off-shore –  $\text{mass} = k(\text{length})^3$
- Nonstructural carbon fiber
  - Single thermal insulation application requires 500 tons of fiber per year
  - Additional application for graphite electrodes would require 500 tons of fiber per year
  - Filtration
  - Adsorption





# Potential automotive market alone is huge for low-cost carbon fiber

Carbon fiber potential in 2017 at 50% of current price

Global Automotive Production by Car Type in 2017	Expected Vehicle Production in 2017	Expected use of CF in Cars	Carbon Fiber Demand (M lbs) @ 0.50 X current price	Carbon Fiber Demand (\$ M) @ 0.50 X current price
<p><b>Super Cars</b></p>	6K	100% of cars	1.3 M lbs	\$7 M
<b>Super Luxury Cars</b>	600K			
<b>Luxury Cars</b>	4 Million	10%	101.2 M lbs	\$506 M
<b>Other/Regular Cars</b>	92 Million	1%	202.4 M lbs	\$1,012 M
<b>Global Automotive Production in 2017</b>	<b>97 Million</b>		<b>305 M lbs</b>	<b>\$1,525 M</b>

Source: Lucintel, ACMA Composites 2012

~ 3X current global CF demand for ALL APPLICATIONS

# The CFTF has three primary missions

Demonstrate low-cost carbon fiber (LCCF) technology scalability

Produce quantities of LCCF for large-scale material and process evaluations and prototyping

Partner with educational institutions to develop a skilled workforce

***CFTF is the bridge from R&D to deployment and commercialization***

*Relevance*



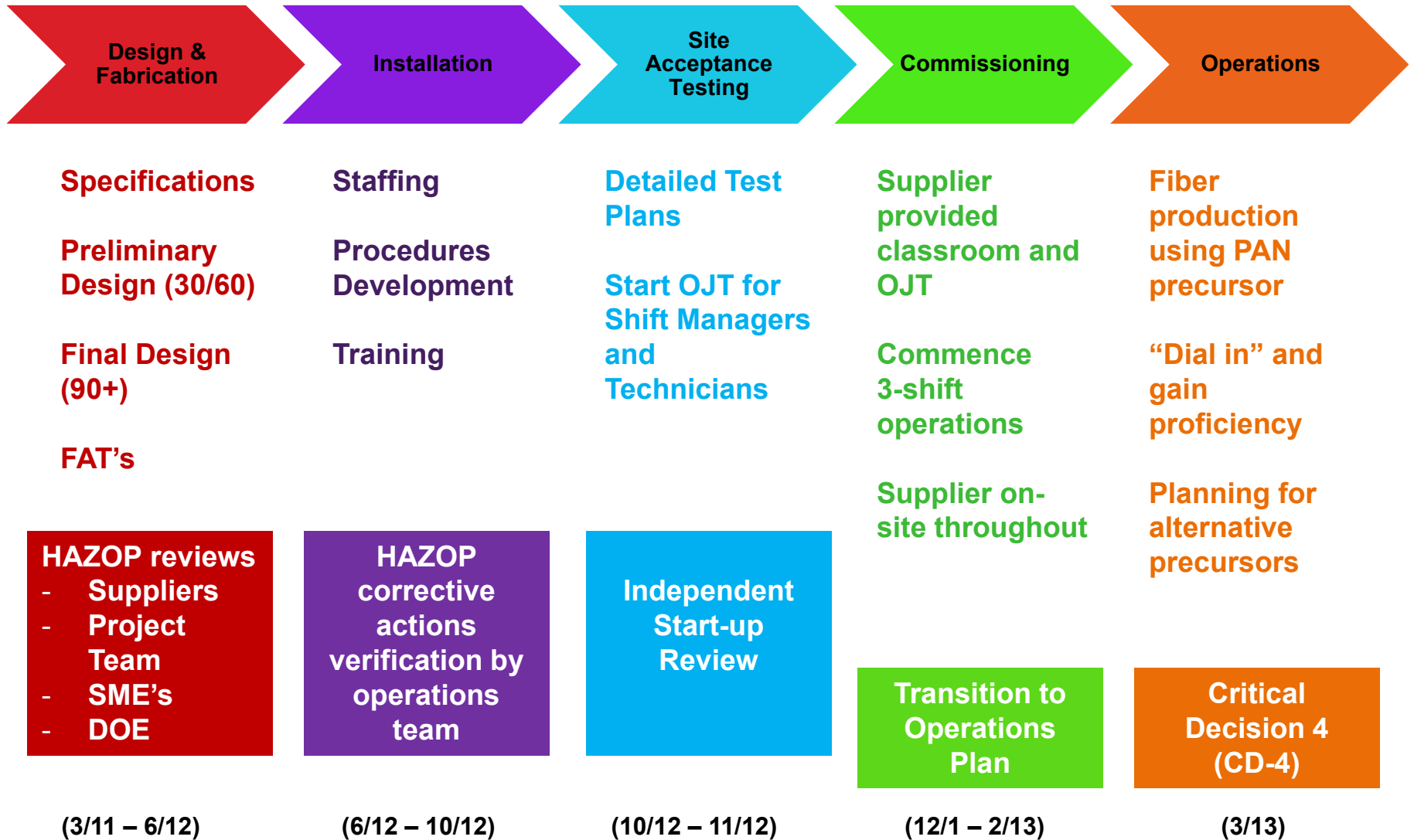
# CFTF is the world's most capable open-access carbon fiber manufacturing facility

- Alternative precursor materials
- Multi-component structural fiber extrusion technologies
- Alternative conversion technologies
- New surface treatment and sizing technologies
- Product development using LCCF



*The CFTF serves as a national asset to assist industry in overcoming the barriers of carbon fiber cost, technology scaling, and product and market development*

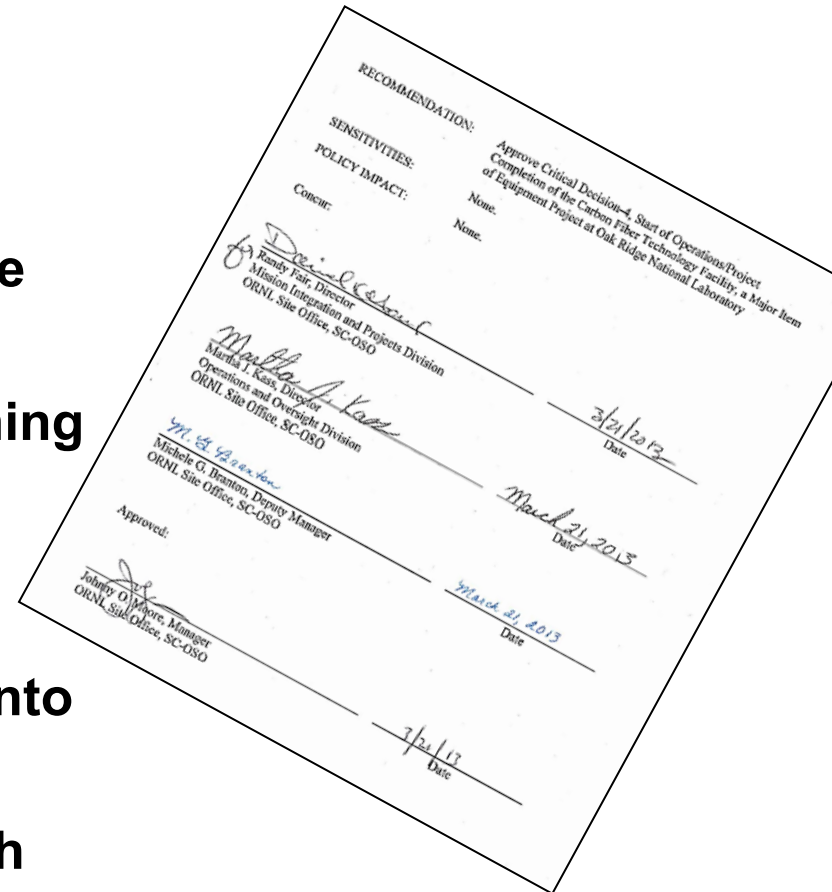
# Project Deployment Phases





# Capital project was completed 6 months ahead of schedule and \$2.5M under budget

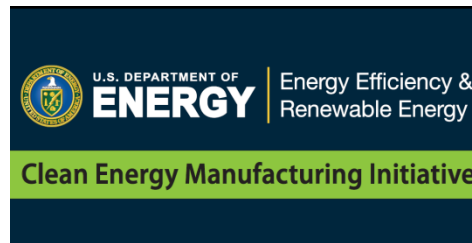
- Executed project per DOE Order 413.3B
  - Met or exceeded all project Key Performance Parameters
- Utilized streamlined small business contracting mechanisms to accelerate installation
- Built strong start-up and commissioning team
  - Key personnel recruited with relevant experience
  - Adequate training time was built into schedule
- Cultivated excellent relationships with suppliers and potential industry partners



# The CFTF was officially dedicated on March 26, 2013



Ribbon cutting (l to r): Council on Competitiveness President & CEO Deborah Wince-Smith, Congressman Chuck Fleishmann, DOW executive Florian Schattenmann, Governor Bill Haslam, ORNL Director Thom Mason, Assistant Secretary for EERE David Danielson, and Ford executive Jim DeVries.



## Dr. David Danielson announcing the Clean Energy Manufacturing Initiative



Gary Lownsdale, Chief Technology Officer, Plasan Carbon Composites introducing the new Corvette hood to VIP guests



Dr. Danielson hosted a round-table event to discuss details of the Clean Energy Manufacturing Initiative



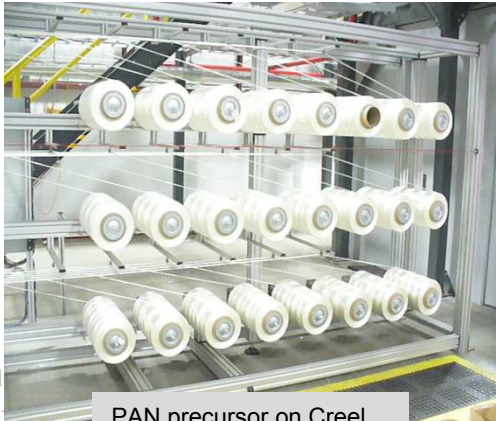
Elizabeth Wayman, Director for the Clean Energy Manufacturing Initiative hosted a panel session exploring resources and opportunities in clean energy manufacturing

# Key accomplishment: Carbon fiber exceeding target properties achieved at first production attempt using PAN as baseline

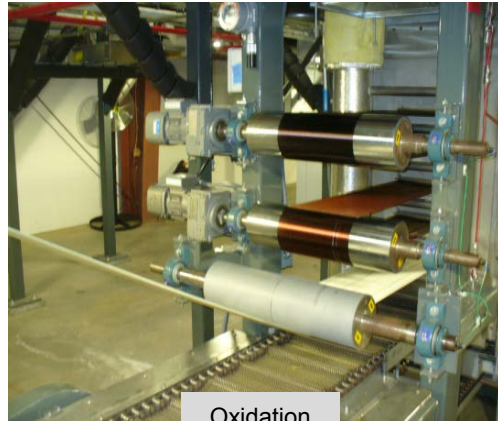
Target Properties: 250 ksi tensile, 25 Msi modulus, 1% elongation to break

Lot Summary for Lot Number PW241130230 – Commissioning Run 1 with 24K Tow

Take-up Position	Fiber Diameter (microns)	Single Filament Test Method			Full Tow Test Method		
		Tensile Strength (Ksi)	Tensile Modulus Young's Modulus (Msi)	Elongation Strain at Break (%)	Tensile Strength (Ksi)	Tensile Modulus Chord Modulus (0.1 - 0.6%) (Msi)	Elongation Strain at Break (%)
2	7.75	450.2	30.349	1.396	387.4	31.161	2.626
10	8.29	402.2	29.407	1.330	351.2	30.708	1.768
22	8.43	470.4	29.083	1.562	373.8	30.263	2.210
1	8.04	475.2	30.965	1.497	368.0	33.392	1.412
12	7.49	512.7	30.273	1.596	374.7	32.035	1.679
14	7.80	448.8	31.546	1.376	348.7	32.166	1.417
<b>Avg. =</b>	<b>7.97</b>	<b>459.9</b>	<b>30.271</b>	<b>1.460</b>	<b>367.3</b>	<b>31.621</b>	<b>1.852</b>
<b>SD =</b>	<b>0.35</b>	<b>36.5</b>	<b>0.924</b>	<b>0.108</b>	<b>14.9</b>	<b>1.140</b>	<b>0.479</b>
<b>Count =</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>



PAN precursor on Creel



Oxidation



Oxidized PAN ready for carbonization



# Key accomplishment: Linked with local community college for highly successful workforce development

- Established Technician Internship program
- Developed Technician training system to be used a national asset to support industry growth
- Developed modern media-based real-time work control system – Patent filing in process

Chemistry & Mathematics	Mechanical Skills	Safety Aspects	Process Controls	“Black Art”
<ul style="list-style-type: none"><li>• Correct process upsets</li><li>• Prevent excursions</li></ul>	<ul style="list-style-type: none"><li>• Equipment adjustments</li><li>• In-process maintenance</li></ul>	<b>HAZARDS:</b> <ul style="list-style-type: none"><li>• Chemical</li><li>• Thermal</li><li>• Mechanical</li><li>• Electrical</li><li>• Environment</li></ul>	<ul style="list-style-type: none"><li>• Alarm response</li><li>• Controls logic</li><li>• Process adjustments</li></ul>	<ul style="list-style-type: none"><li>• Pressure &amp; flow balancing</li><li>• Splicing</li><li>• Tow repairs</li></ul>





# Key accomplishment: Project safety and compliance – zero injuries or events

## Significant safety hazards and controls implemented

Consideration	Controls
<b>Electrical/High Voltage</b>	<ul style="list-style-type: none"><li>• Lockout/Tagout</li></ul>
<b>Heat stress</b>	<ul style="list-style-type: none"><li>• 7.5 air changes per hour in high bay</li><li>• Hydration, cool breaks, clothing, outages</li></ul>
<b>Dissociation in high-temperature furnace</b>	<ul style="list-style-type: none"><li>• Lock-out wet fire protection in area above furnace</li><li>• Water deflection at furnace entry/exit</li><li>• Auto E-stop if any sprinklers deploy</li></ul>
<b>Walking/working surfaces</b>	<ul style="list-style-type: none"><li>• OSHA compliant platforms</li><li>• Fatigue mats</li></ul>
<b>Thermally hot surfaces (tow, melt spinner)</b>	<ul style="list-style-type: none"><li>• Specially designed tools, training</li></ul>
<b>Pinch points and rolling parts</b>	<ul style="list-style-type: none"><li>• Dress requirements</li><li>• Plentiful E-stops</li></ul>
<b>Hydrogen cyanide gas</b>	<ul style="list-style-type: none"><li>• Thermal oxidation unit</li><li>• Atmospheric vent system</li><li>• HCN monitors at oven/furnace entrance &amp; exits</li></ul>
<b>Uncontrolled exotherm in ovens</b>	<ul style="list-style-type: none"><li>• Oven quench system</li></ul>

# ORNL resource contributions without direct project expense

## Facilities Development

- Jack Stellern
- Randy Pickens
- Mark Turner
- Don Sokel
- Jane Holly
- Chris Tavino
- Wayne Smathers

## Equipment Design

- Cliff Eberle
- Bob Norris
- Felix Paulauskas

## Real Estate/Lease/ Building Maintenance

- Doug Rose
- Ellen Reeves

## Legal

- Andrea Reagan

## Energy & Environmental Sciences

- Suzy Fowler (DOM)
- David Fowler

## Health & Safety (Overall)

- Kris Thomasson
- David Fowler

## Environmental & Waste Management

- Jim Eaton
- Don Naab

## OSHA

- Andrew Bush

## Quality

- Judah Wilkins

## Training

- Allen White
- Sharon Byrd

## Electrical Safety

- Mark Matthews

## Fire Protection

- Harvey Goranson

## Physical Security

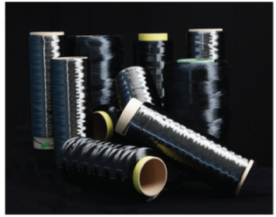
- John Watkins
- Brent Holden

## IT/Cyber Security

- Jess Wales
- Dave Wantland
- Eddie Bishop

## Emergency Management

- Rick Rodreguez



# ORNL is formally collaborating with over 40 companies on LCCF technology and commercialization

- 3M Company
- ABC Group Sales & Engineering
- Advanced Composites Group
- Alpha Industries
- ATK Launch Systems
- BASF Corporation
- Chomarat NA, LLC
- Composite Applications Group
- Continental Structural Plastics
- Cytec Carbon Fibers
- Dow Chemical Company
- Despatch Industries
- Faurecia
- Fibria
- Ford Motor Company
- General Electric
- Global Composites Solutions
- Graftech International
- Hanwha Azdel
- Harper International
- Hills, Inc.
- Innovation Valley Inc.
- Innventia
- INOAC USA
- Lignol Innovations
- Materials & Chemistry Laboratory
- Metalsa Structural Products
- NFT, Inc.
- NovusFolium
- Plasan Carbon Composites
- Sabic Innovative Plastics
- SGL Carbon Fibers
- Sodra Innovation
- SSOE Group
- Steelcase
- Swift Engineering
- Toho Tenax America
- United Technologies Research Center
- United States Enrichment Corp. (USEC)
- Virdia, Inc.
- Volkswagen Group of America



# First competitively awarded project to buy time at CFTF

- Dow and Ford team up to bring low-cost, high-volume carbon fiber composites to next-generation vehicles
  - Reducing weight of new cars and trucks by up to 750 lbs by the end of the decade
  - Foundational work at ORNL on low-cost precursors key to automotive applications
  - DOE and state of Michigan fund \$13.5M research agreement to develop lower cost carbon fiber production process using polyolefin in place of conventional polyacrylonitrile (PAN) as feedstock
  - Novel process could reduce production cost by 20%
  - High-volume commercial launch anticipated outcome





# Potential Partnerships under discussion

- **Harper, International, with expressed interest in bringing existing and future clients to run trials at the CFTF**
- **GrafTech™, in development lignin-based carbon fiber for high insulation applications. A DOE proposal has been submitted to support the full scale commercialization of this material.**
- **Kaltex Group, a North American company a major producer of textile-grade polyacrylonitrile fibers.**
- **Domtar, who recently announced a large investment supported by DOE and USDA in its Plymouth, NC plant to produce 75 tons per day of a new clean lignin (“BioChoice”). Domtar is working closely with ORNL to explore the conversion of this material into lignin-based carbon fiber.**
- **Plasan Carbon Composites, who has an R&D Center located at ORNL's Science and Technology Park, and is working on several projects with ORNL, including one project funded by DOE. Plasan was recently been awarded a large contract to produce parts for the 2014 Corvette.**
- **Composites Application Group, with space in the Oak Ridge Science and Technology Park and an active project in carbon fiber utilizing fiber from the Carbon Fiber Technology Facility**

# Summary

- **Relevance**

- The CFTF is the bridge from R&D to large-scale commercialization of low-cost carbon fiber in U.S.

- **Approach**

- Dr. David Danielson, March 26, 2013: "My staff has called this project a text book example of perfect execution and have told me that they have never seen a project run so well."

- **Technical Accomplishments and Progress**

- Project completed 6 months ahead of schedule and \$2.5M under budget
- Carbon fiber with good properties produced on first try

- **Collaborations/Partnerships**

- Capital project phase: Harper, Hills, ESG Construction
- **Future: Numerous opportunities being deliberately pursued**